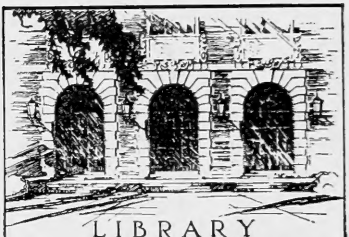
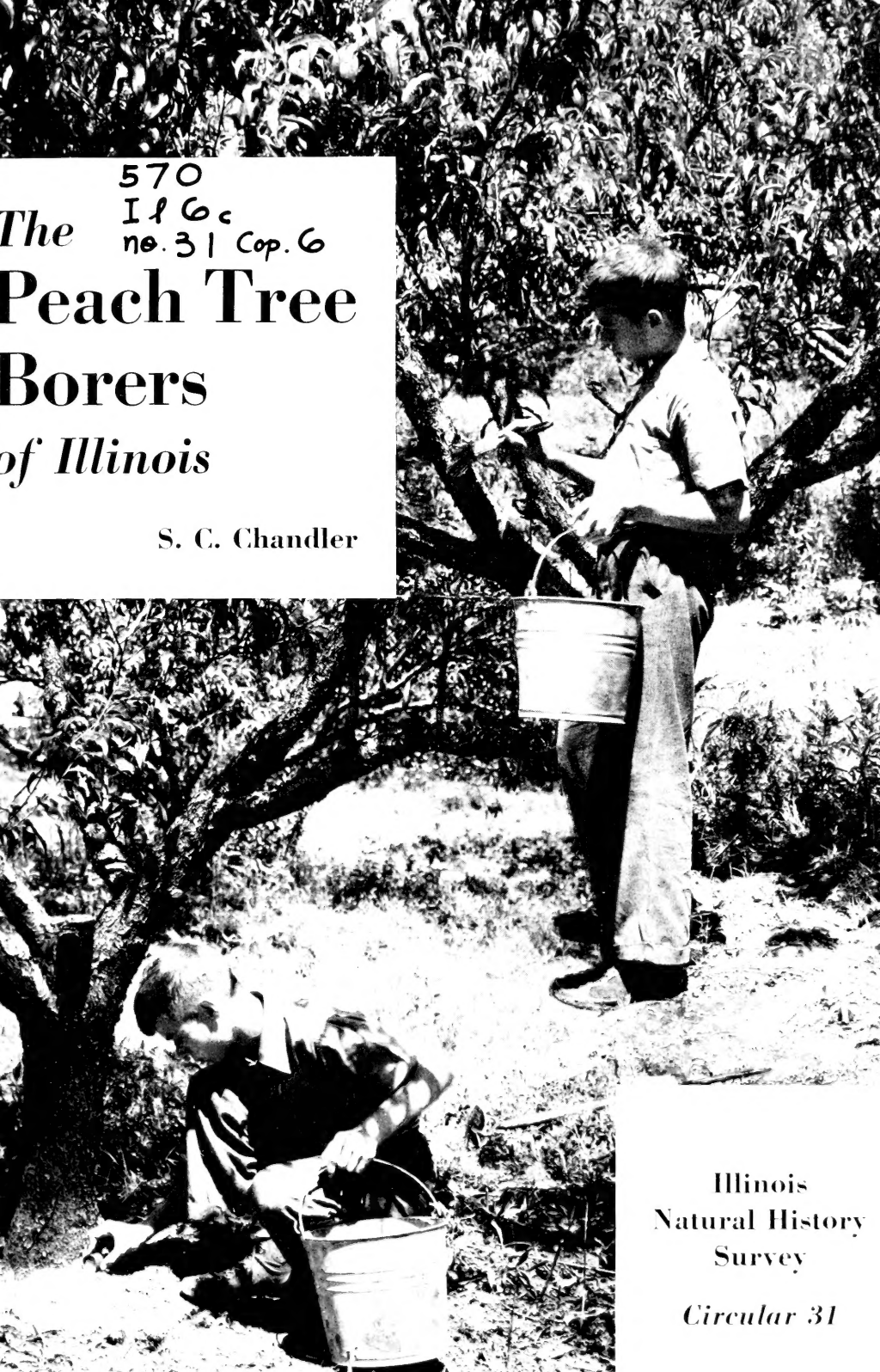


The Peach Tree Borers of Illinois

S. C. Chandler



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Circular 31

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The Peach Tree Borers of Illinois

S. C. CHANDLER

NATURAL HISTORY SURVEY DIVISION
THEODORE H. FRISON, *Chief*

Circular 31 Urbana February 1939

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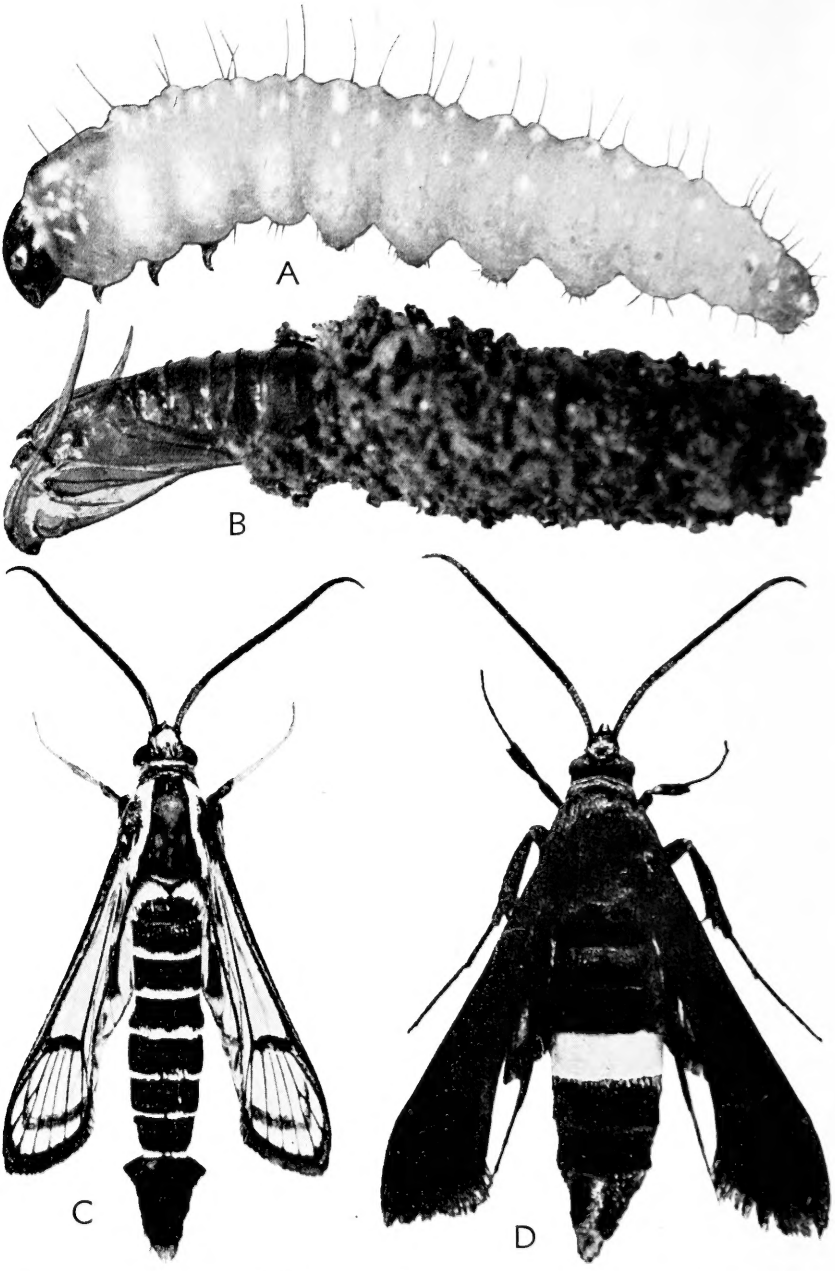

Peach borer, *Conopia exitiosa* (Say). The peach borer passes the winter as a worm or larva, A, which, during the following spring and summer, feeds on the inner bark of the tree. In summer it spins a cocoon, B (right), in which it changes to a pupa, of which the skin is shown, B (left), and from which it emerges 18 to 30 days later as a moth: C, male moth; D, female moth. The female moth lays eggs from which larvae hatch. All figures four times natural size.

The PEACH TREE BORERS *of Illinois*

S. C. CHANDLER

THE peach borer, *Conopia exitiosa* (Say), is generally considered the most important insect enemy of the peach tree in Illinois. Although easily controlled, it is seldom eradicated and in this state is found to some extent in all peach orchards three years of age or older. Even orchards one and two years old may become seriously infested.

Peach Borer Life History Studies

Peach borers pass the winter as whitish larvae, one-quarter inch to slightly over an inch in length. These worms are usually found most abundantly at the base of peach trees just below the ground line, but they may be found as much as 10 inches above or below this line. The presence of borers is indicated by masses of gum, mixed with frass or sawdust, exuding from the tree trunks, fig. 1.

During the spring and summer, the worms (frontispiece) feed on the inner bark of the trees. They become full grown at any time between the middle of June and the first of September. They then spin cocoons of silk, incorporating in them bits of frass. In these cocoons they change to the brown pupal stage (frontispiece), emerging from 18 to 30 days later as clear-winged moths (frontispiece).

The moths are in appearance similar to large wasps. The average life of the moths is six days, during which time the female, fig. 2, lays from 400 to 1,000 eggs. The eggs are placed singly on or around the base of the trunks of peach and related trees. In from 7 to 10 days, small white worms with brown heads hatch from these eggs. The worms crawl over the outer bark and, on finding a crack, they rapidly gnaw their way into the inner bark. Here they continue to feed until cold weather. There is but one brood a year.

Moth Emergence

Our life history studies have been concerned largely with moth emergence because of its direct bearing upon proper times of treatment for borers. For a period of six years, from

1924 to 1929, inclusive, emergence records were kept in a number of orchards in the vicinity of Carbondale. During the early part of this period, moth-tight cages were constructed around the base of infested trees to catch the moths as they emerged.

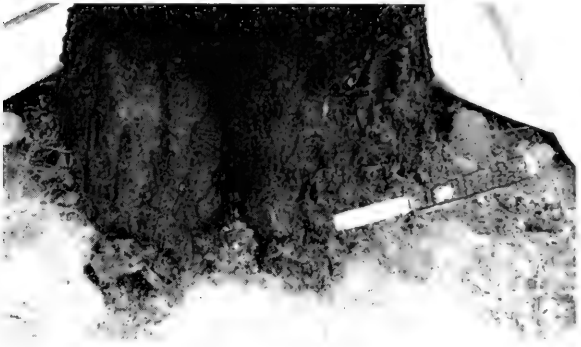

Fig. 1.—Shown here at the base of a tree is the exudate (indicated by knife) resulting from peach borer attack. Frass and gum at the base of a peach tree are indications that peach borers are at work or have been at work on the inner bark.

Fig. 2.—Adult female of the peach borer, natural size, on white arrow that points to the exudate at the base of the tree and the pupal skin from which the moth has emerged. The average life of the moth is six days, during which the female lays from 400 to 1,000 eggs. There is but one brood each year; moths emerge between late June and early October.

Later, the daily emergence record was made by noting the number of fresh pupal skins at each examination.

An examination of these data shows very little variation from year to year, and it seems best to combine the data from the six years, presenting them in the form of a graph. This necessitates grouping the records. In fig. 3, graphically recording emergence of peach borer moth from 1924 through 1929, the records are shown in weekly periods, from the last week in June until the middle of October. This graph shows emergence starting late in June and ending October 10. In the period covered by the graph, the peak was reached in the last week of

August. From the week ending August 22 to that ending September 19, 67 per cent of the emergence took place.

Location of Entrances

Another phase of our life history studies which has a practical aspect relates to the amount of frass and exudation visible without the removal of any soil from the base of the tree. Growers frequently follow the practice of treating only those trees that show gum and frass, commonly called borer signs. The purpose of this phase of our study was to discover whether infestation by peach borers could be detected by superficial examination of the tree.

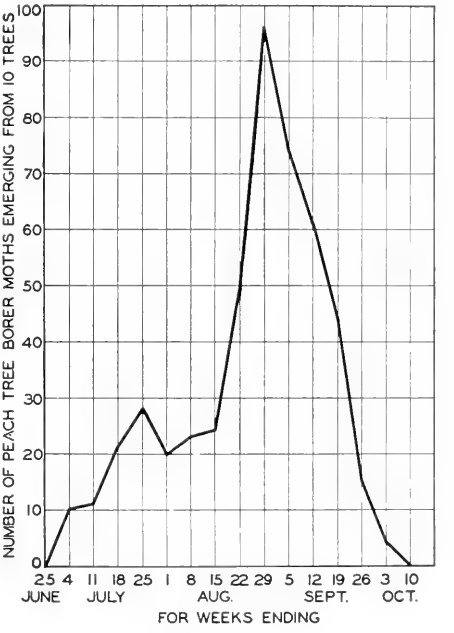

Fig. 3—Graph illustrating composite records of peach borer emergence in orchards near Carbondale, 1924–29. The records for the six years are combined and shown in weekly periods. Emergence is shown as starting late in June and ending October 10; the peak as being reached the last week in August. The greater part of emergence, 67 per cent, is shown taking place between August 22 and September 19. The recommendations contained in this circular for control of peach borers are based upon these records because of the direct bearing of moth emergence upon proper times of treatment for the borers.

In the fall of 1934, 50 trees, 10 in each of 5 orchards, which at the surface of the soil showed no signs of borers, were examined to determine the degree of infestation.

Of the 50 apparently uninfested trees, borers were found in 29. The borers, 107 in number, were distributed as follows: First orchard, 48 borers divided among 10 trees; second orchard, 33 borers divided among 9 trees; third orchard, 2 borers divided between 2 trees; fourth orchard, no borers in any of the 10 trees; fifth orchard, 24 borers divided among 8 trees.

It is evident from this investigation that presence of borers frequently cannot be detected by surface examination. However, we found that, in most trees harboring borers, removing

an inch or less of soil would have revealed the presence of gum and frass.

Control of the Peach Borer

Since the discovery in 1919 of the value of paradichlorobenzene,* commonly called PDB, for the control of the peach borer, much experimental work has been done by entomologists of Illinois and other states and of the United States Bureau of Entomology and Plant Quarantine on the many important details of the operation known to the peach grower as gassing the borer. In Illinois, control tests began in 1920, and almost every year since some studies for the control of this insect have

Fig. 4.—Application of PDB for control of the peach borer. Left, the ring of PDB around tree trunk on leveled ground. Right, the mound around the base of the treated tree.

been made. From time to time some of the information gained has been given out in the form of articles, state horticultural society reports and unpublished talks at fruit growers' meetings. It is the purpose of this publication to summarize the results of our peach borer studies and bring them up to date, and to include information on the other borers of the peach tree, the lesser peach borer, bark beetle and shot-hole borer.

Method of Treating for the Peach Borer

The commonly recommended method for gassing the peach borer is as follows: Scrape earth from around the trees sufficiently to allow spreading of the PDB crystals. Apply the crystals in the form of a ring far enough from the trunk to prevent their touching the bark (cover and fig. 4). Use from

*As the name paradichlorobenzene (the chemical is sometimes called by growers "Painless Death to Borers") is difficult to remember and pronounce, the abbreviation PBD has become common and will be used hereafter in this publication.

one-fourth to one-half ounce PDB crystals on one- and two-year trees; up to 2 ounces on large, old trees. Recommended amounts for trees of various ages are given on page 8. Cover

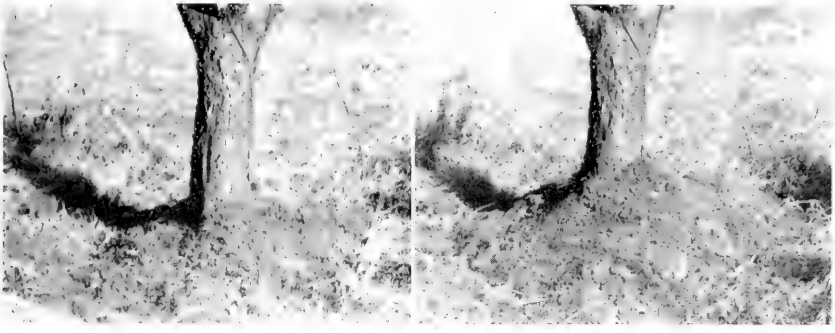

Fig. 5.—Left, peach tree with mound sufficiently large for PDB crystals. Right, peach tree with mound needlessly large.

the PDB with four to six spadesful of earth and tamp the earth down with the back of the spade.

In our years of observation of growers' treatments and in our own tests we have found that successful control of borers with crystals is obtained with much less mounding than some growers think necessary. On trees 10 years old, five or six spadesful of earth are required to go around the base. Control is not helped by adding more earth, nor should any appreciable reduction be made in the amount used. See fig. 5.

Injury from PDB Crystals and Treatment of Young Trees

Much experimental work on peach borer control has been done because of the fact that PDB may, under certain circumstances, injure peach trees. Typical injury is shown in fig. 6. It may consist of only a slight flecking of the outer bark layers, or of a coalescing of the flecks into dark spots. The spots may be small, or they may be so large that they entirely girdle the tree. They may affect only outer bark layers or they may extend into the cambium.

The subject of injury to young peach trees by crystaline PDB has been of little concern to Illinois growers. In 1920, 1921 and 1922, tests were conducted in a number of places in southern Illinois on one-, two- and three-year old trees to study this question, with the result that no injury was observed so long as the crystals were not allowed to touch the bark. As a

result of these tests we suggested in Circular 8* the use of three-fourths ounce of the material on trees as young as two years old and one-half ounce on younger trees, but we withheld

Fig. 6.—Injury from PDB (paradichlorobenzene) crystals, ranging from few flecks, A, at the left side of the part of tree that has been cut, to blackened areas on the right side, B.

unqualified recommendations until further experimental work could be done. In Circular 26†, published in 1935, we suggested the use of one-half ounce on trees one full year old.

In the fall of 1937, tests conducted jointly by the Illinois Natural History Survey and the United States Bureau of Entomology and Plant Quarantine on trees of different ages showed that the younger the trees the greater was the probability of injury. The 5- and 13-year old trees used in the test were not injured. On the other hand, under circumstances of rather high soil temperatures, 20 per cent of the two-year old trees treated with one-fourth ounce PDB showed spots which, though small, penetrated into and severely injured the cambium.

With nursery stock, 20 per cent of two-year rootstocks and 100 per cent of all June buds were severely injured by one-eighth ounce PDB. From the tests made it appears unsafe to use PDB crystals on nursery stock.

We are still of the opinion that orchard trees one full year old or older can be treated with comparative safety. For 15 years, one- and two-year old trees in Illinois have been treated with PDB crystals, and in the close contact which we have had

*Flint, W. P., and S. C. Chandler. The Peach Borer and Methods of Control. Illinois Natural History Survey Circular 8. 1922.

†Chandler, S. C., and W. P. Flint. Insect Enemies of the Peach in Illinois. Illinois Natural History Survey Circular 26. 1935.

with the growers of the state we have never heard of or observed any serious injury to or loss of trees from PDB correctly applied. Undoubtedly, some injury takes place at times, but less than might occur if the trees were left to the borers.

It is our suggestion that growers continue treating young trees as in the past but that they consider first the need for treatment. Many orchards are two or three years old before showing any appreciable infestation, and growers should make examinations to ascertain that treatment is needed before it is applied.

Removal of Mounds

A number of experiment stations advise the removal of mounds from young trees in from three to six weeks after treatment, because of the assumption that gas will become concen-

Fig. 7.—Removing mounds. This operation should be completed by the first of July.

trated in the pores of the soil as increasing amounts of it are evolved from the PDB crystals. We have felt that under Illinois conditions sufficient gas will escape to prevent a damaging concentration. Removal of mounds shortly after treatment is almost never practiced in Illinois, and over a long period of years we have detected no ill effects from leaving the mounds until the following spring.

In the spring or early summer, however, mounds made the previous year should be removed, fig. 7. A large proportion of borer eggs are laid on the tree trunks at the ground line, and many young borers enter the bark at the same place. To destroy

Fig. 8.—Peach trees ranging in diameter from 12 inches to 17 inches are common in old orchards in Illinois and require from 1¼ to 2 ounces of PDB crystals per tree for peach borer control.

eggs and borers with the usual PDB mounding treatment, successively higher mounds must be made each year, unless the ground around the trees is leveled before the moths begin laying eggs. Fig. 3 indicates that, in the peach growing region of southern Illinois, moths begin emerging the last of June. Therefore, growers have until the first of July to remove mounds made the previous year. This gives them the opportunity to include mound removal as a part of their spring disking and hoeing, after first growth of grass and weeds has started.

Amounts of PDB Crystals for Trees of Different Ages

Fear of possible injury to trees has largely determined amounts of PDB crystals recommended. In the first years of our experimental work, we treated one-year old trees with as much as three-fourths ounce PDB per tree on several occasions without loss of a tree or even observable injury. Two tests with 1½ ounces per tree on two-year old trees gave similar results. Further tests, however, have shown that much smaller amounts of PDB give borer control.

Basing our recommendations on data we have from Illinois and other states, we suggest the use of one-fourth ounce PDB crystals on trees one full year old, one-fourth to one-half ounce on two-year old trees and three-fourths ounce on trees three to five years old.

Amounts used on older trees should be proportional to the circumference of the trunks. For most bearing trees, 1 ounce per tree is sufficient, but in many orchards 1½ ounces are needed. We have in Illinois at the present time many peach orchards 12 to 20 years old with trees having diameters of 12 to

17 inches, fig. 8. A test conducted on 13-year old trees revealed that as much as 2 ounces of PDB may be necessary in some cases. Results of the test are given in table 1.

Table 1.—Results of test in which various amounts of PDB were used on 13-year old trees treated at Centralia, October 19, 1922, and examined November 10, 1922.

AMOUNT PDB PER TREE	TREES TREATED	BORERS ALIVE	BORERS DEAD	TOTAL BORERS	PER CENT OF BORERS DEAD
1 ounce	10	4	23	27	85.2
1½ ounces	10	5	47	52	90.4
2 ounces	10	1	59	60	98.3

Accuracy is important in the application of PDB crystals. Such measures as spoonful or handful are inaccurate and may result in damage to trees or ineffective treatment. Measuring cups that hold an ounce of PDB crystals are supplied by insecticide dealers. These may be used when an ounce is the specified dosage, or they may form the basis for the selection of other measures holding the exact amount of crystals prescribed.

Time of Application

Fall is the usual time of treating for the peach borer, but we have many inquiries from growers who have discovered after it is too late for fall treatment that they have a serious infestation. They wish to know whether they should treat in

Fig. 9.—Method of obtaining results of peach borer tests; soil removed and worms cut out with knife. This slow and laborious job was the only method of peach borer control before the introduction of PDB.

the spring or wait until the following fall. Data pertinent to these inquiries have been collected, fig. 9.

Comparison of Seasons.—Table 2 gives a summary of all our fall and spring tests in which PDB crystals were applied in the recommended amounts and at times and under conditions of soil temperature which would be considered advisable for orchard treatment. Data on those treatments applied under unusual conditions have been omitted.

This table shows that spring treatments have given from 77.8 per cent to 95.2 per cent kill and have averaged 83.4 per cent. The fall treatments have ranged from 85 per cent to 100 per cent kill and have averaged 94.2 per cent. The variation over a period of 8 springs and 14 falls is shown in table 2.

Table 2.—Results of spring and fall treatments with PDB crystals for peach borer in Illinois. This table includes data on all tests in which recommended amounts of PDB were applied under normal orchard conditions.

	Spring Applications			Fall Applications		
Year	Trees Treated	Total Borers	Per Cent of Borers Dead	Trees Treated	Total Borers	Per Cent of Borers Dead
1920	20	162	77.8	40	47	100.0
1921	90	93	81.7	130	127	98.4
1922	30	21	95.2	30	139	92.8
1923	20	36	83.3	60	120	85.0
1924	—	—	—	39	78	94.9
1925	—	—	—	30	66	87.9
1926	10	19	84.2	20	88	98.9
1929	—	—	—	20	23	95.7
1930	—	—	—	15	1	100.0
1932	—	—	—	20	49	98.0
1934	—	—	—	20	32	93.8
1935	10	41	92.7	20	56	98.2
1936	10	20	95.0	70	144	93.8
1937	25	55	87.3	28	90	95.6
All years	*215*	*447*	*83.4*	*542*	*1060*	*94.2*

Best Dates for Spring Treatments.—Spring treatments should be made as early as temperature conditions are favorable. Temperature records kept in connection with tests indicate that adequate control can be obtained when soil temperatures in the mounds at the level of the material, fig. 10, are from 55 to 60 degrees for a few days. More rapid volatilization of PDB crystals occurs when the temperature is somewhat higher. To the grower, however, this information is not so important as an answer to his question of when to treat. Date-of-treatment tests

Fig. 10.—Soil thermograph and thermometer used in determining temperatures suitable for volatilization of PDB crystals.

were conducted in southern Illinois for a three-year period. A summary of these tests is given in table 3.

Although not extensive, these tests indicate that treatments with PDB crystals made in southern Illinois in April

Table 3.—Results of tests made to determine best spring dates for applying PDB for peach borer control in southern Illinois. These results indicate that in the latitude of Carbondale PDB crystals are consistently effective as early as the first of May.

DATE OF TREATMENT	TREES TREATED	BORERS ALIVE	BORERS DEAD	TOTAL BORERS	PER CENT OF BORERS DEAD
March 31, 1920	10	42	12	54	22.2
April 15, 1920	10	30	15	45	33.3
May 1, 1920	10	18	66	84	78.6
May 15, 1920	10	18	60	78	76.9
Check, no treatment	10	61	6	67	8.9
April 14, 1921	10	11	0	11	0.0
May 2, 1921	5	0	5	5	100.0
May 17, 1921	15	1	15	16	93.7
April 15, 1922	10	0	3	3	100.0
May 1, 1922	10	0	8	8	100.0
May 15, 1922	10	1	9	10	90.0
Check, no treatment	10	14	1	15	6.7

give unsatisfactory results but that those made the first of May and later are relatively effective. Spring treatments, however, cannot be expected to give as good results as fall treatments.

Best Dates for Fall Treatments.—Two factors determine optimum times for fall treatments: (1) date of latest entrance by the borers and (2) soil temperatures. These are related to two questions which growers ask: (1) How early should we treat? (2) How late should we treat?

The moth emergence chart, fig. 3, shows that in southern Illinois moths are still emerging in large numbers as late as September 19, in moderate numbers as late as September 26 and in small numbers as late as October 3. Since all eggs are not laid for some days after the moths emerge, it is evident that borer attack in southern Illinois continues into October. The presence of tiny borers always found late in October substantiates this statement.

In an effort to learn whether borer attack in southern Illinois orchards continues into October, trees of a Carbondale orchard were treated at different dates in the late summer and fall of 1923. Table 4 gives the results of these tests. It brings out the fact that, even as late as September 15, the treatment failed to kill 9.1 per cent of the borers which entered above the mound, but that no live borers were found following the October 1 treatment.

Table 4.—Total number of borers found and live borers found above mounds in treated orchard near Carbondale, 1923.

Date of Treatment	Trees Treated	Number of Borers Found		Per Cent of Borers Above Mound
		Total	Above Mound	
August 18	10	7	4	57.1
September 1	10	11	7	63.6
September 15	20	11	1	9.1
October 1	20	33	0	0.0
October 13	20	77	0	0.0

We recommend that growers in southern Illinois do not treat earlier than September 25 and that, preferably, they wait until October 1.

The question of how late to treat probably could be answered, as already indicated, by reference to soil temperatures, 55 degrees F. being considered as about the minimum for effective volatilization of the crystal PDB. There are at times

some difficulties in interpreting soil temperature records, and they are not generally available. So the grower is desirous of knowing what calendar dates he can depend upon for effective treatment.

Tests conducted near Carbondale over a period of eight years show that treatment is consistently effective in southern Illinois as late as October 15. A summary of the data on this point, giving number of borers concerned and annual fluctuation in control, is presented in table 5.

Table 5.—Results of tests made to determine best fall dates for applying PDB for peach borer control in southern Illinois. These results indicate that in the latitude of Carbondale PDB crystals are consistently effective as late as October 15.

DATE OF TREATMENT	TREES TREATED	BORERS ALIVE	BORERS DEAD	TOTAL BORERS	PER CENT OF BORERS DEAD
October 14, 1920	10	0	15	15	100.0
October 17, 1921	10	0	5	5	100.0
October 12, 1922	10	0	5	5	100.0
October 19, 1922	20	1	59	60	98.3
October 13, 1923	20	14	63	77	81.8
November 1, 1924	10	2	27	29	93.1
October 24, 1925	20	4	39	43	90.7
October 13, 1932	20	1	48	49	98.0
October 15, 1937	8	3	34	37	91.9
All treatments	*128*	*25*	*295*	*320*	*92.2*

Differences in weather between southern and central Illinois indicate that the most favorable dates for treatments in the latitude of Centralia are between September 20 and October 5. In peach districts north of Centralia, treatments should be made between September 15 and October 1.

Every year we find numbers of growers desirous of treating later than October 15. They inquire how much later they can successfully treat. To answer this question, treatments have been made over a period of years as late as the first week of November. A summary of these data is given in table 6.

In the tests recorded in table 6, the 1920 treatments were decidedly ineffective. In 1923 no treatments were made later than October 13, but as the results of the treatment made at this date were only fair it is safe to assume that later treatments would have given even lower rates of kill. The results in 1924 and 1937 were satisfactory, though not so good as would have been obtained under higher soil temperatures.

From the data we have, we conclude that, in about three out of five years, satisfactory control of peach borers can be

Table 6.—Results of tests with PDB crystals to determine effectiveness in southern Illinois of treatments for peach borer control made as late as the first week of November.

DATE OF TREATMENT	TREES TREATED	BORERS ALIVE	BORERS DEAD	TOTAL BORERS	PER CENT OF BORERS DEAD
November 1, 1920	10	16	10	26	38.5
November 3, 1921	10	0	6	6	100.0
October 13, 1923	20	14	63	77	81.8
November 1, 1924	10	2	27	29	93.1
November 1, 1937	7	2	22	24	91.7

obtained by PDB crystals as late as November 1 in the latitude of Carbondale. We have made no similar tests farther north.

Frequency of Treatment

A very practical question asked by growers relates to frequency of treatment. For two successive years, 30 orchards were examined. These fell into three groups: One group was treated one year before examination; one, two years before; and one, three years before. In each orchard, 100 trees were examined. The test involved in all 6,000 trees located in 60 orchards. Table 7 gives the results of these surveys.

Table 7.—Borer-infested trees per 100 in orchards treated one, two and three years before examination.

TREES LAST TREATED	INFESTED TREES PER 100 IN 1933	INFESTED TREES PER 100 IN 1934	AVERAGE FOR THE TWO YEARS
One year before	6.2	14.3	10.3
Two years before	36.1	48.9	42.5
Three years before	54.6	56.5	55.6

This table indicates that on the average an orchard not treated for two years will have four times as many borer-infested trees as an orchard untreated for one year. The infestation does not continue to increase at the same rate for the years following the second, but trees untreated for three years have an accumulation of unhealed injury not indicated in these data.

We conclude that if a grower wishes to economize by decreasing the number of peach borer treatments, he could probably omit treatments for one year without much permanent damage to his trees, since he would kill most of the borers the following fall before they do considerable feeding. However, we believe he would be very unwise to omit treatment for two successive years.

A practice which has considerable merit and is economical is known as "treat a year and patch a year." Growers who follow it treat their trees thoroughly every other year. In alternate years they patch; that is, they treat only those trees that show, above the ground line, indications of borer infestation.

Removal of Grass and Weeds Before Treatment

Early directions for borer treatment included careful cleaning of the ground around the base of the tree before application of the crystals. As a result of these directions, many growers have spent and some now spend altogether too much time on this cleaning operation. Soon after the introduction of PDB into Illinois for borer control, tests were begun to determine the need for removal of grass and weeds or for preparation of the soil. They are summarized in table 8.

Table 8.—Results of tests to determine need for removal of grass and weeds prior to treatment with PDB crystals.

	Grass Removed			Grass Not Removed		
Time of Treatment	Number of Trees Treated	Total Number of Borers	Per Cent of Borers Dead	Number of Trees Treated	Total Number of Borers	Per Cent of Borers Dead
Fall, 1922	6	3	100.0	6	2	100.0
Spring, 1923	10	15	80.0	10	21	85.7
Fall, 1923	30	87	82.8	30	33	90.9
Fall, 1924	10	27	96.3	10	22	95.5
Fall, 1925	10	60	98.3	10	28	100.0
Fall, 1932	10	24	100.0	10	25	96.0
Fall, 1934	10	11	100.0	10	16	81.3
All treatments	*86*	*227*	*91.2*	*86*	*147*	*92.5*

These tests, extended over seven seasons, show conclusively that the removal of grass and weeds does not increase the control of the borer. The only reason for the operation is to facilitate the spreading of the crystals. The trees used in the plots in which the grass was not removed had in most cases a considerably thicker growth of grass around the base than is found in the average orchard and were selected because of this fact. Fig. 11 shows the extent of the growth in a typical orchard used in the test.

Substitutes for PDB Crystals

Four characteristics are sought in any substitute for PDB crystals: First, low cost; second, safety on young trees; third,

Fig. 11.—Typical tree with excess growth of grass and weeds around base as used in grass removal tests.

efficiency; fourth, effectiveness at low temperatures. We consider the first two characteristics the most important of the four. Probably the hope of finding a safer substance has been the greatest incentive in the search for a new material over the country at large.

Although Illinois growers have little fear of serious injury on young trees, there is real need for a safe material for use on nursery stock. Certainly some injury from PDB crystals occurs under certain circumstances to Illinois orchard trees. If a material could be found combining all or even most of the desirable characteristics suggested, a real contribution to peach borer control would be made.

Solid Substitutes.—Four solid materials were tested during the seasons of 1925 to 1930 inclusive, all of them proposed by chemical or insecticide companies as possible inexpensive substitutes for PDB. None proved to be of value.

Liquid Substitutes.—Oliver I. Snapp of the United States Bureau of Entomology and Plant Quarantine, in tests over a period of years in Georgia, has shown that applications of cottonseed oil emulsion impregnated with PDB may be sprayed around

the base of peach trees with the probability of less injury from it than from crystal PDB. His results show at least as good control with this combination as with the crystal PDB. From time to time other liquids, not containing PDB, have been suggested and tried.

In Illinois we have tested mineral oils as carriers of PDB and have favored them because of their cheapness and availability. We have tested two materials not containing PDB, dichloropentane and *Scalecide*, suggested by manufacturers of insecticides. We have also tested soybean oil as a carrier of PDB. In table 9 are summarized our tests with these materials for the falls of 1934 and 1935 and the intervening spring.

Table 9.—Results of tests with liquids on peach trees 10 years old for control of peach borer in southern Illinois, fall of 1934 and spring and fall of 1935.

TREATMENT	NUMBER OF SEASONS	TREES TREATED	TOTAL BORERS	BORERS DEAD	PER CENT OF BORERS DEAD
Liquids Containing PDB					
PDB in *Dendrol*	3	30	83	80	96.4
PDB in *Scalecide*	2	20	51	49	96.1
PDB* in *Scalecide*	1	10	29	17	58.6
PDB in soybean oil	2	20	34	31	91.2
Liquids Without PDB					
Dichloropentane, 1 ounce per tree	2	20	53	37	69.8
Dichloropentane, 2 ounces per tree	3	30	87	83	95.4
Scalecide, 1 in 8	2	20	45	10	22.2
Check, no treatment	3	35	103	3	2.9
Crystal PDB, standard (1 ounce per tree)	3	50	129	123	95.4

*Each tree received a dilution containing one-fifth ounce PDB as compared with 1 ounce in each of the three other treatments containing PDB.

Our procedure when testing the PDB crystals in oils was to dissolve 2 pounds of the crystals in 1 gallon of oil and dilute with water to make 4 gallons. We then applied 1 pint of the diluted mixture to a mature tree. This gave each tree 1 ounce of PDB, the same dose it would receive in the crystal treatment. Mounding was done as in the crystal method.

In the case of *Scalecide* without PDB, the directions of the manufacturer were followed. The dirt was removed from the base of the tree as for worming, gum rubbed off with a sack and 1 quart of a dilute mixture, 1 part of *Scalecide* to 8 parts water,

sprayed at the base of the tree. At the suggestion of the manufacturer, a similar dilution of *Scalecide* containing one-fifth ounce PDB was tested in the same way.

Fig. 12.—Liquids for peach borer control may be poured around the tree, but this method of application increases the problem of carrying liquid in the orchard.

Other liquids were either sprayed with a bucket sprayer or poured, figs. 12, 13, 14. In the case of dichloropentane, 1 or 2 ounce dosages were applied per mature tree.

All of the tests recorded in table 9 were on trees 10 years of age or older. No injury was observed following any of the treatments, but Mr. Snapp, working with some of the materials in Georgia at the same time on trees of various ages, reported very severe injury with dichloropentane used at strengths which gave good control.

The tests recorded in table 9 show that control as good as that given by the standard PDB crystal treatment was obtained by the application of 1 pint *Dendrol* or *Scalecide* dilution per tree when the dissolved PDB was used in amounts equal to the standard. They show approximately the same control with 2 ounces of dichloropentane, and poor results with *Scalecide* diluted 1 in 8.

In the late summer and early fall of 1937, the Illinois Natural History Survey and the United States Bureau of En-

tomology and Plant Quarantine conducted cooperative experiments in southern Illinois in which vegetable and mineral oils were tested as carriers of PDB. Also tested were ethylene dichloride and dichlorethyl ether, two liquids not containing PDB. In table 10 are given results of these cooperative tests, made under the direction of Mr. Snapp and the writer.

Tests recorded in table 10 show that control as good as that with the standard PDB crystals was obtained with all materials tested except dichlorethyl ether, and that almost as good control was obtained by a reduction of about 25 per cent in the amount of PDB incorporated into the carriers. Cottonseed oil gave a little better control than did the mineral oils when used as a carrier of PDB. Injury by PDB was discussed on page 5.

Of the materials tested in this experiment, ethylene dichloride looks especially promising.

In tests conducted on nursery stock, so few borers were found that control tests were not conclusive and they are not

Fig. 13.—Soil often needs some cupping or working to prevent run-off of liquid applied for peach borer control.

Fig. 14.—A few shallow cuts may be made with a spade in the soil around peach tree to prevent run-off of liquid.

included in table 10. However, the finding of more borers in the check plots than in the treated indicates that control was obtained by the use of liquids containing very small quantities of PDB. In one of the treated plots, each nursery tree received a one-eighth ounce dosage of PDB in liquid; in the other plot, each tree received one-sixteenth ounce.

Spraying and Pouring Liquids.—In the tests recorded in table 10, most of the plots treated with liquids were divided into

Table 10.—Results of tests with liquids for control of peach borer, made in late summer and early fall of 1937, the Illinois Natural History Survey and the United States Bureau of Entomology and Plant Quarantine cooperating.

Plot No.	Treatment	Trees Treated	Total Borers	Borers Dead	Per Cent of Borers Dead
	Materials Containing PDB				
1	Crystal PDB, standard				
	13-year trees, 1 oz. per tree	10	32	32	100.0
	5-year trees, ¾ oz. per tree	10	21	20	95.2
	2-year trees, ¼ oz. per tree	10	0	0	——
2	PDB in cottonseed oil emulsion*				
	13-year trees, 1 oz. in ½ pt. per tree	10	33	33	100.0
	13-year trees, ¾ oz. in ½ pt. per tree	10	26	24	92.3
	5-year trees, ¾ oz. in ½ pt. per tree	10	15	15	100.0
	5-year trees, ½ oz. in ½ pt. per tree	10	4	4	100.0
	2-year trees, ¼ oz. in ¼ pt. per tree	10	0	0	——
	2-year trees, ⅛ oz. in ¼ pt. per tree	10	0	0	——
3	PDB in mineral oil emulsion†				
	13-year trees, 1 oz. in ½ pt. per tree	10	32	29	90.6
	13-year trees, ¾ oz. in ½ pt. per tree	10	41	39	95.1
	5-year trees, ¾ oz. in ½ pt. per tree	10	8	8	100.0
	5-year trees, ½ oz. in ½ pt. per tree	10	39	38	97.4
	2-year trees, ¼ oz. in ¼ pt. per tree	10	2	2	100.0
	2-year trees, ⅛ oz. in ¼ pt. per tree	10	2	1	50.0
4	PDB in equal parts cottonseed and mineral oil† emulsions				
	13-year trees, 1 oz. in ½ pt. per tree	10	56	52	92.9
	13-year trees, ¾ oz. in ½ pt. per tree	10	61	60	98.4
	5-year trees, ¾ oz. in ½ pt. per tree	10	17	17	100.0
	5-year trees, ½ oz. in ½ pt. per tree	10	6	6	100.0
	2-year trees, ¼ oz. in ¼ pt. per tree	10	4	4	100.0
	2-year trees, ⅛ oz. in ¼ pt. per tree	10	5	5	100.0
7	PDB in *Dendrol*				
	13-year trees, 1 oz. in ½ pt. per tree	10	37	36	97.3
	5-year trees, ¾ oz. in ½ pt. per tree	10	6	6	100.0
	2-year trees, ¼ oz. in ¼ pt. per tree	10	3	3	100.0
	Materials Not Containing PDB				
5	Ethylene dichloride emulsion				
	13-year trees, ½ pt. 25% emulsion per tree	10	76	76	100.0
	13-year trees, ½ pt. 20% emulsion per tree	10	30	29	96.7
	5-year trees, ½ pt. 20% emulsion per tree	10	13	13	100.0
	5-year trees, ½ pt. 15% emulsion per tree	10	0	0	——

Table 10—Concluded.

PLOT NO.	TREATMENT	TREES TREATED	TOTAL BORERS	BORERS DEAD	PER CENT OF BORERS DEAD
	2-year trees, ¼ pt. 20% emulsion per tree	10	5	5	100.0
	2-year trees, ¼ pt. 15% emulsion per tree	10	3	3	100.0
12	Dichlorethyl ether dissolved in water at rate of 30 cc. in 1 gal.				
	13-year trees, 1 pt. per tree	5	16	3	18.8
	13-year trees, ¾ pt. per tree	5	15	9	60.0
	5-year trees, ¼ pt. per tree	5	0	0	—
6	*Check, no treatment*				
	13-year trees	5	43	2	4.7
	5-year trees	5	35	3	8.6
	2-year trees	10	5	0	0.0

*All emulsions, 50 per cent stock. †Viscosity, 491.4.

two parts; in one part the liquids were sprayed at the base of the tree with a bucket sprayer and in the other the liquids were poured, fig. 12. A summary of all the results gives the following percentages of dead borers: 96.1 per cent in plots in which the liquid was sprayed; 97.7 per cent in plots in which the liquid was poured. Under certain circumstances it might be of importance to know that liquids give as good results when poured as when sprayed.

Comparison of Solids and Liquids

The use of PDB crystals for peach borer control, now a long established practice, is relatively cheap, requires very little skill or equipment and is effective. Although under certain conditions some injury occurs, growers are not likely to make a change unless they can see sufficient advantages. For this reason we have tried to explore all the possible advantages of the liquid method and to compare them with those of the crystal method.

Injury.—Injury by PDB has already been discussed on page 5. No material has yet been found that we are certain will give no injury under any circumstances, but some effective liquids, such as ethylene dichloride and PDB in cottonseed oil emulsion, are apparently a little safer than PDB crystals.

Effectiveness at Low Temperatures.—Because of their

physical characteristics, liquids are likely to become effective more quickly than solids. For this reason they might be effective at lower temperatures or might utilize to better advantage very short periods of high temperature. Tests with ethylene dichloride made in New York state by Mr. Snapp gave good results at low temperatures.

A test of ethylene dichloride emulsion was begun November 18, 1937, in southern Illinois at soil temperatures which remained almost stationary at 35 degrees F. during the first four days, varied from 30 to 40 degrees during the next four days and attained a maximum of 52 degrees on the two days before the examination, 11 days after treatment. On December 3, a treatment was made with this material and with crystal PDB for comparison. Temperatures following this treatment ranged only from 35 to 40 degrees. Examinations were made on December 16. Table 11 gives the results of these tests.

Table 11.—Results of tests for effectiveness of ethylene dichloride used against peach borers in southern Illinois at low temepratures ranging from 30 to 52 degrees F., autumn, 1937.

Material, Date of Treatment and Temperature Range	Trees Treated	Total Borers	Borers Dead	Per Cent of Borers Dead
Ethylene dichloride, November 18, 30–52 degrees	10	41	34	82.9
Ethylene dichloride, December 3, 35–40 degrees	5	20	18	90.0
PDB crystals, December 3, 35–40 degrees	5	10	1	10.0

Apparently ethylene dichloride has the advantage of being effective at lower temperatures than is crystal PDB.

Further tests under conditions of cold soil were conducted in March, 1938, in Jackson and Johnson counties by the Illinois Natural History Survey, represented by the author, and the United States Bureau of Entomology and Plant Quarantine, represented by Mr. Snapp. Three weeks intervened between treatment and worming. In this time, soil temperatures averaged each week from 50.2 to 55.3 degrees with minimums of 43 and a maximum one day only of 64. Ethylene dichloride emulsion and dichlorethyl ether, each at different strengths, were compared with crystaline PDB on trees of three different ages. Table 12 summarizes the results.

Table 12.—Results of tests for control of peach borer by ethylene dichloride emulsion and dichlorethyl ether under conditions of low soil temperature at Carbondale, March, 1938.

AGE OF TREES	MATERIAL USED	AMOUNT PER TREE	TREES TREATED	TOTAL BORERS	PER CENT OF BORERS DEAD
10 years	Ethylene dichloride	½ pt. of 25%	20	134	97.0
10 years	Ethylene dichloride	½ pt. of 20%	20	186	92.5
10 years	Dichlorethyl ether	1 pt.*	10	60	96.7
10 years	Dichlorethyl ether	¾ pt.*	10	46	95.7
10 years	PDB crystals	1 oz.	10	35	34.3
10 years	Check, no treatment	——	5	28	0.0
4 years	Ethylene dichloride	½ pt. of 20%	10	85	97.6
4 years	Ethylene dichloride	½ pt. of 15%	10	53	96.2
4 years	Dichlorethyl ether	¾ pt.*	10	96	92.7
4 years	Dichlorethyl ether	½ pt.*	10	112	82.1
4 years	PDB crystals	¾ oz.	10	116	87.1
4 years	Check, no treatment	——	5	80	0.0
2 years	Ethylene dichloride	¼ pt. of 15%	20	52	92.3
2 years	Ethylene dichloride	¼ pt. of 12½%	20	51	94.1
2 years	Dichlorethyl ether	½ pt.*	10	35	82.9
2 years	Dichlorethyl ether	¼ pt.*	10	22	81.8
2 years	PDB crystals	¼ oz.	10	54	16.7
2 years	Check, no treatment	——	5	14	0.0

*Diluted, 30 cc. dichlorethyl ether to 1 gallon water.

This experiment indicates that ethylene dichloride emulsion applied at strengths shown in table 12 will give very effective control of the peach borer at temperatures which are not high enough for good control by PDB crystals. It also indicates that dichlorethyl ether may give fairly good control under these conditions. The experiments made in the late summer and early fall, when soil temperatures were higher, were not very favorable to dichlorethyl ether, table 10.

Necessity for Mounding.—Because of their physical state, it is conceivable that liquids applied for peach borer control might not need mounding. This conception was tested during the spring and fall of 1936. PDB was dissolved in *Dendrol* at the usual rate of 2 pounds of crystals to 1 gallon of the emulsion and diluted with water so that when each tree was treated with 1 pint of material it received 1 ounce of PDB. Four tests were conducted in two orchards over two seasons. Trees were 10 and 11 years old. Table 13 gives the results.

Table 13 shows only one test in four in which control in unmounded trees equaled or bettered that in the mounded, and the averages for the 210 trees treated and nearly 500 borers

concerned showed a kill that was 21.6 per cent less in the unmounded than in the mounded trees. Obviously, liquid treatment does not lessen the necessity for mounding.

Table 13.—Results of tests to determine necessity of mounding after liquid treatments.

	Trees Mounded			Trees Not Mounded		
Test Number	Trees Treated	Total Borers	Per Cent of Borers Dead	Trees Treated	Total Borers	Per Cent of Borers Dead
1	10	22	100.0	10	22	86.4
2	25	52	90.4	25	130	68.5
3	50	107	97.2	50	96	70.8
4	20	40	87.5	20	25	88.0
All tests	*105*	*221*	*94.1*	*105*	*273*	*72.5*

It has been stated that mounds for trees given the liquid treatment need not be made so large as those for trees given the crystal treatment, fig. 5, and need not be tamped down. We have made no tests to determine the validity of this statement, but in view of the above experiment it seems rather doubtful. In the 1937 cooperative experiment, results of which are shown in table 10, liquid-treated trees were given a minimum amount of mounding and no tamping, but no comparison was made with crystal-treated trees with respect to size of mounds.

Equipment Required.—The liquid treatment requires the handling of 8 to 16 times as much weight as does the crystal treatment.

The most economical method of applying the liquid is usually with the power sprayer, which the orchardist already possesses. The life of a spray machine and the cost of maintenance is, in general, inversely proportional to the amount of use given it. Estimates from growers of large acreages in Illinois indicate that the cost is approximately $2 in depreciation, repairs and upkeep, not including gasoline and oil, to operate a sprayer for one day. In an actual test, described below, one-half gallon of gasoline at .18 cents per gallon was required to operate a sprayer one hour. To the cost of the sprayer must be added the expense involved in having it pulled by a team or tractor.

A regulator has been devised, fig. 15, which may be attached at the end of the spray hose for liquid treatments. This is necessary so that the right amount of liquid, no more and

no less, may be applied to each tree. Selling at the present time for $20, this piece of equipment could be made by a mechanically trained grower for less if his time were not considered, and

Fig. 15.—Regulating device in operation. With this device a measured half pint or pint of liquid can be sprayed around the base of trees for peach borer control.

probably if any great demand should develop it could be produced commercially more cheaply than at present. Every man applying the liquid must be equipped with the device, and the number of men working at this operation is limited by the supply of regulators.

The fact has been brought out on page 21 that, in the application of the liquid, pouring is as effective as spraying. If liquid were poured around each tree, the use of the sprayer and regulating device would, of course, be eliminated. However, the problem of carrying the necessary large amount of liquid from tree to tree remains. The amount of time required by this method and present labor prices must be considered in figuring its cost.

Time Required.—In the spring and fall of 1937, two tests

were run under orchard conditions to determine the actual time required to treat by the liquid and the crystal methods. In the Hartline Orchards, Union County, the tests covered an area of 7½ acres. In the Heaton Orchards, Johnson County, they covered about 18 acres.

In all orchards, the liquid treatment was given by one man with a power sprayer and a regulating device; the pressure in the sprayer was reduced to 100 pounds. No driver except the operator was used, a saving that is possible only with steady, dependable teams. Two men followed the sprayer, mounding. Time-out was taken for every interruption, so that the records include only the actual time of work. In the crystal-treated blocks of the Heaton Orchards, records were kept of a crew of nine men, three to apply the crystals and six to mound.

The average time required to treat and mound a tree was 1.4 minutes by the liquid method and 2.0 minutes by the crystal method, or a saving of 30 per cent in time by the liquid method.

On the basis of a common wage in Illinois orchards, 15 cents per hour or one-fourth cent per minute, the following calculations were made:

Liquid treatment, 1 tree (1.4 man-minutes) cost $0.0035 (about one-third cent).

Crystal treatment, 1 tree (2.0 man-minutes) cost $0.0050 (one-half cent).

It therefore cost $0.0015, approximately one-seventh cent, more per tree for labor to treat by the crystal than by the liquid method.

In these tests, 3 gallons of gasoline were required to keep the engine running for 6 hours. This was equivalent to 5 gallons for a 10-hour day. Oil and gas together for a day cost at least $1. The average number of trees treated by a sprayer in one day was 427. The cost of the gas and oil, therefore, amounted to $0.0023 (about one-fourth cent) per tree, approximately 50 per cent more than the amount saved by the greater speed of the liquid method. The item of $2 per 10-hour day for depreciation and repair of spray rig added another $0.0047 (about one-half cent) per tree to the cost of the liquid treatment.

The cost of such items as filling the spray rig, heating and preparing the material, hitching and unhitching the team, and repairing possible spray-rig breakage was not considered in the calculations.

Cost of Materials.—Price of the material is another im-

portant item in a comparison of liquid and crystal treatments. At a retail price of 18 cents per pound in 100-pound lots, the price which now prevails, and at the amount of 1 ounce PDB per tree, the cost of the material for the crystal treatment is slightly more than 1 cent per tree, or about twice the cost of the labor required to apply it. Obviously, the cost of oils used as carriers must be considered. Prices of these materials vary from year to year, but, if used at the dilutions indicated, even the cheapest of the carriers will add from three-fourths to 1 cent per tree, which almost doubles the cost of materials.

The greatest hope for economy is from the materials which do not contain PDB. Ethylene dichloride at the present price of 6½ cents per pound in 50-gallon drums costs approximately 1 cent per tree. Dichloropentane can now be obtained for 5 cents per pound in single barrel lots. If this is applied at the rate of 2 ounces per tree, the cost is about $0.007 (slightly less than three-fourths cent) per tree. However, insufficient work has been done with this material, and because of severe injury in Georgia we do not at the present time recommend it.

Summary of the Solid and Liquid Methods.—Following is a summary of the facts that have become apparent through comparison of the solid and liquid methods of treating for peach borer control:

1.—To date only one solid, crystal PDB, is known to be both safe enough and cheap enough to use.

2.—Four liquid substitutes tested, cottonseed oil emulsion, mineral oil emulsion and miscible oils, all impregnated with PDB, and ethylene dichloride emulsion (without PDB) are as effective under normal treating temperatures as PDB crystals. These substitutes appear to be a little less likely to injure the tree than are the crystals.

3.—When the soil is cold, ethylene dichloride emulsion is more effective than PDB crystals.

4.—Mounding is necessary after liquid treatments, though possibly the mounds need not be so large as when crystals are applied.

5.—Cupping may be necessary under certain soil conditions to prevent run-off when liquids are used.

6.—Liquid substitutes found safe and efficient are all more expensive than PDB crystals with the exception of ethylene dichloride emulsion, which costs about the same.

7.—The liquid method of treating trees is 30 per cent

faster than the crystal method if the liquid is sprayed on the trees with a gasoline driven machine.

8.—The use of a spray machine for applying the liquid entails the purchase of a special regulating device which limits the number of operators.

9.—Under Illinois conditions the financial gain from the 30 per cent saving in time, possible with the liquid treatment, is offset by any one of several items of expense connected with the use of a sprayer and team.

10.—If the liquid material is poured around the trees, no time is saved, and the carrying into the orchard of weight eight times that of crystal PDB necessitates the use of a team and probably is more expensive and less simple an operation than the crystal treatment.

THE LESSER PEACH BORER

As the lesser peach borer, *Synanthedon pictipes* (G. & R.), works in crotches and wounds of peach trees, fig. 16, rather than at the base, it does not girdle the trees. It is termed "lesser"

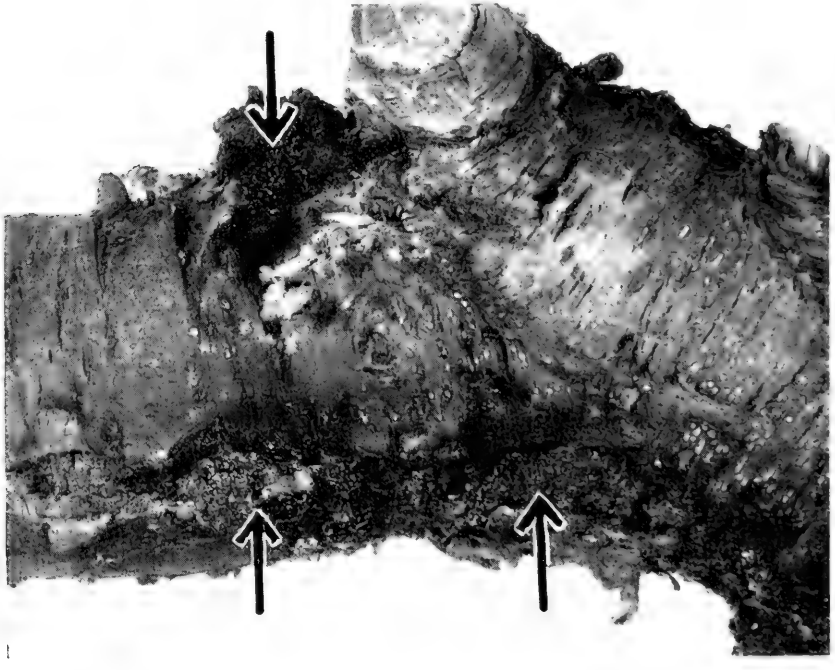

Fig. 16.—Injury caused by lesser peach borer, *Synanthedon pictipes* (G. & R.).

Fig. 17.—Wounded areas and weakened crotches on peach trees are especially subject to attack of lesser peach borer.

because the damage it does is not so great as that done by the peach borer, *Conopia exitiosa* (Say).

Extent of Injury

In our observations we have found the lesser peach borer working usually in places on the tree previously weakened or injured. Weakened crotches, areas on the trunk skinned by a tractor, sun-scalded and winter-injured branches, and branches broken by heavy crops are favored places of attack, fig. 17. There is evidence to show that some of the splitting of crotches which occurs would be avoided if it were not for the additional weakening caused by the borers working at a critical point. Needless to say, any horticultural practice that will avoid injuries to the trees will help to control this insect.

In order to learn something of the prevalence of the lesser peach borer in actual percentages, examinations were made in 10 representative commercial orchards of bearing age in southern Illinois. Fifty trees, scattered over each orchard, were examined and a record made of the infestation. A tree with one or more injured areas was classed as infested.

Degree of infestation among the orchards ranged from 10

to 32 per cent. Of all trees examined in the 10 orchards, 22.6 per cent were infested with the lesser peach borer.

Control Measures

Since the lesser peach borer usually works too high on the tree to be covered with a mound, most growers have relied on the old jack-knife and wire method formerly used on the peach borer, fig. 9. With the introduction of the liquid method of peach borer control, it was suggested by Mr. Snapp that some of the materials used would control the lesser peach borer. In our control experiments for this latter insect, we used materials at strengths sufficient for peach borer control and also at even greater strengths.

Experimental Work

In our observations of liquid applications for the peach borer in actual orchard practice, it was evident that the operator has neither liquid enough in the half pint or pint applied per mature tree, or time enough before his automatic cut-off stops him, to treat anything but the base of the tree, and he is not likely in this one operation to do any treating for the lesser peach borer.

For this reason we confined our tests to painting the affected areas, fig. 18. When the gum could easily be removed, this was done before the material was applied, but when, as often

Table 14.—Results of experiments for control of lesser peach borer by insecticides painted on affected areas. The experiments cover spraying seasons in the years 1934-37.

Materials Used	Stock, Pounds PDB Per Gallon	Dilution, Ounces PDB Per Pint	Seasons Tested	Trees Treated	Total Borers	Per Cent of Borers Dead
PDB in *Dendrol*	2	1	3	38	47	51.1
PDB in *Dendrol*	2	2	5	70	83	86.7
PDB in *Dendrol*	4	4	2	35	27	100.0
PDB in soybean oil	2	1	1	10	23	8.7
PDB in *Niagara Tar Oil*	2	2	1	10	16	93.8
PDB in *Niagara Tar Oil*	2	4 (Undiluted)	1	10	10	100.0
Dichloropentane	—	Undiluted	1	10	24	70.8
Checks	—	—	5	45	47	0.0

was the case, the gum had hardened it was left undisturbed. Good penetration of the gas, however, resulted even in the latter situation, and excellent control was obtained. The materials tested were those used for peach borer control with the addition of one other. They are indicated in table 14, which gives the results of the experiments.

No injury could be observed in the areas receiving any of the materials. The infested areas are usually somewhat corky and protected by outer bark and by several layers of inner bark. If the paint is applied chiefly to the place showing infestation, there seems to be little danger of injury, even at the strengths used. In one of the tests, the lower half of tender shoots of the current season, growing up in the center of the tree, were painted; the upper parts were left for checks. With the dichloro-

Fig. 18.—Control of lesser peach borer by painting affected areas of the tree with PDB-oil solution. Even a boy with a bucket of material can treat a large number of trees in a few hours.

pentane and the PDB in *Dendrol* diluted 2 ounces to 1 pint, injury occurred on from 10 to 25 per cent of the shoots, although no injury whatever could be found on the affected areas of the older wood.

Examination of table 14 shows that rather disappointing results were obtained with the strength of PDB in *Dendrol* which gave very satisfactory control for the peach borer when mounding was done. This strength was 2 pounds PDB to 1 gallon *Dendrol*, diluted with water so that each pint of the mixture contained 1 ounce of PDB. However, when that strength was doubled to 2 ounces PDB per pint of mixture, 86.7 per cent kill was obtained as a five-year average.

An attempt was made to increase this strength by dissolving 4 pounds PDB in *Dendrol* and diluting so that each pint of mixture contained 4 ounces PDB. Although this mixture gave better control than the one containing 2 ounces PDB to the pint, it was not satisfactory because of the trouble involved in incorporating such a large amount of the crystal into the oil, the difficulty of keeping it from crystalizing out on cooling and the danger of injury. The same strength could have been obtained by using 2 pounds of PDB to 1 gallon of *Dendrol* and applying without dilution, but it was found that spreading qualities of the paint are much improved when it is diluted with water.

It is probably best in using *Dendrol* to keep close to the proportion of 2 pounds PDB to 1 gallon of the oil and to the dilution of 2 ounces PDB to 1 pint of mixture.

It may be seen in table 14 that the tar oil used gave in the two tests somewhat better control than the miscible oil. Although no injury occurred in our tests, it should be borne in mind that there is a greater probability of injury from a tar oil than from a miscible oil. After five seasons of tests, we do not hesitate to suggest the use of PDB in a miscible oil at the rate of 2 pounds PDB to 1 gallon of oil diluted with water so that there are 2 ounces PDB to 1 pint of mixture.

In making up this material for use in the orchard, if all the stock is to be diluted, 2 pounds of the crystal dissolved in 1 gallon of the miscible oil should be diluted with water to make 2 gallons of mixture. If only a portion of the stock is used, it should be diluted at the rate of 6 parts by volume of the oil-PDB mixture to 4 parts of water. This will give slightly more than 2 ounces PDB to 1 pint of the diluted mixture.

This method of treating lesser peach borers is relatively cheap. A man or even a boy with a bucket of material can cover a large area in a day, examining trees and painting only the spots showing injury. In a trial test over a limited area, 1 pint treated all the infested areas on eight trees. With the material used, PDB in *Dendrol*, the cost amounted to one-half cent per tree.

Time of Treatment

Lack of information on the life history of the lesser peach borer in Illinois makes it impossible to state definitely the best times to treat for it. Our observations indicate that emergence starts earlier in the season than is the case with the peach borer, and it seems probable that treatments should be made in the fall rather than in the spring. The occurrence of a second brood in Illinois is indicated by studies already made in Ohio and West Virginia. With our present knowledge of the insect, we suggest treatment about the same time in the fall as for the peach borer.

THE PEACH BARK BEETLE AND THE SHOT-HOLE BORER

The peach bark beetle, *Phthorophloeus limnaris* (Harr.), and the shot-hole borer, *Scolytus rugulosus* Ratz., attack the trunk and branches of peach trees in Illinois, working especially on weakened trees and branches, figs. 19, 20, 21, 22. The best method of control is to correct whatever has caused the weakness, such as lack of nitrogen, poor drainage, attacks of scale or peach borers, lack of care and cultivation, or winter injury. This is not always possible, however, and at times these insects attack apparently healthy trees. There is need for direct control by insecticides.

Our control experiments with these insects began in 1931 with a test of PDB in cottonseed oil sent by Mr. Snapp from the federal laboratory at Fort Valley, Ga. A kill of 96.5 per cent resulted from the first test.

The following year the same material, possibly deteriorated by this time, was used in another test, and, though as good control was secured, very severe injury and killing of branches resulted, which discouraged us from further trials until the fall of 1935 when tests were started with PDB and miscible oil mixtures.

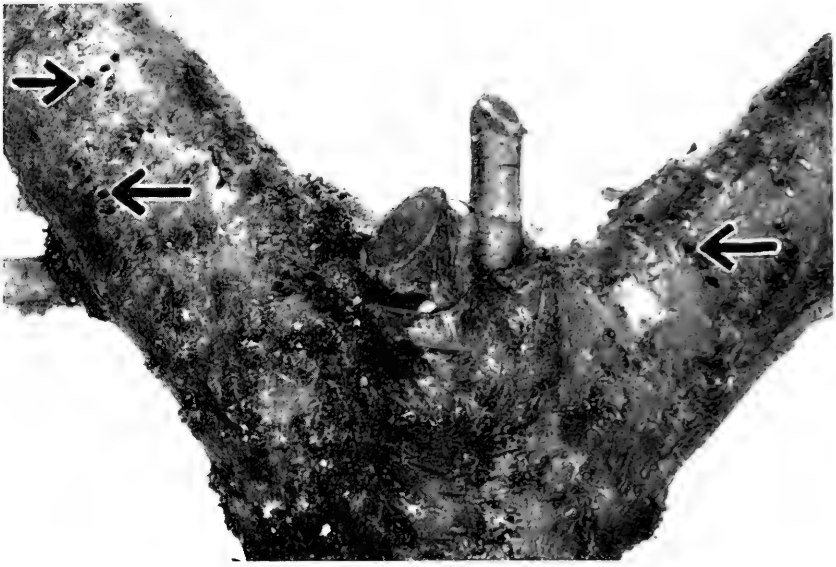

Fig. 19.—Weakened peach branch showing injury by bark beetles, *Scolytus rugulosus* Ratz. Note tiny holes made by beetles, some of holes filled with exuding gum.

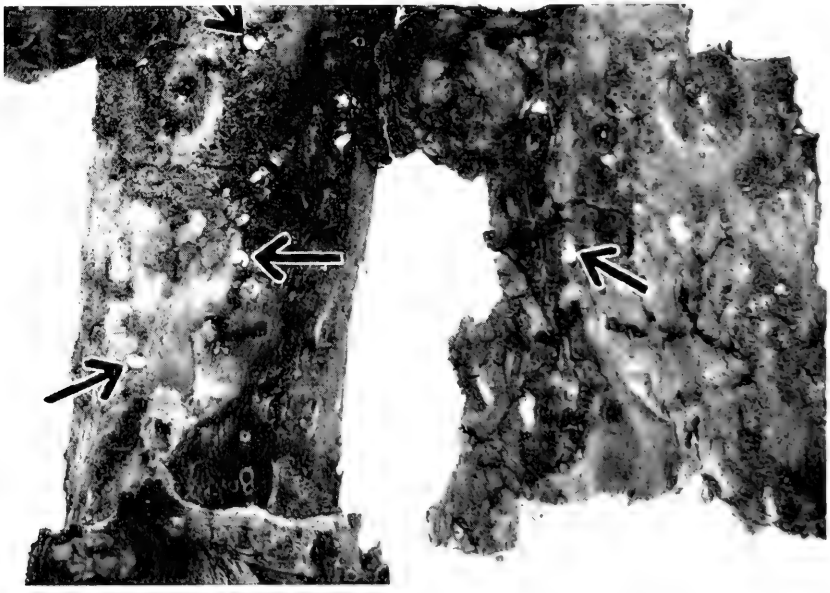

Fig. 20.—Branch of peach infested with bark beetles. The bark has been pulled off to show the white grubs in position.

In tests made in 1935, 1936 and 1938 for control of the shot-hole borer, PDB was dissolved in *Dendrol* at the rate of 2 pounds of PDB to 1 gallon of *Dendrol*. This solution was diluted

Fig. 21.—An infested peach branch that shows burrows of the bark beetle.

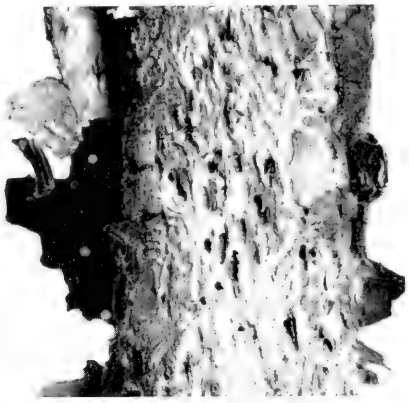

Fig. 22.—Results of bird attack on peach branch infested with bark beetle.

with water. Part was diluted so that each pint of mixture contained 1 ounce of PDB and part so that each pint contained 2 ounces of PDB. Table 15 shows the results obtained.

These tests indicate that with the PDB-*Dendrol* mixture it is possible to attain good control of the beetles but not of the grubs of the shot-hole borer. The reason for this apparently lies in the fact that the beetles stay close to the holes they have made in the bark, whereas, the grubs, after hatching, tunnel too far

Table 15.—Results of 1935, 1936 and 1938 tests for control of shot-hole borer* by PDB in *Dendrol*, a miscible oil. Both beetles and grubs of the shot-hole borer were present in the 1936 and 1938 tests.

Year Tested	Dilution, Ounces PDB Per Pint	Total Beetles	Per Cent of Beetles Dead	Total Grubs	Per Cent of Grubs Dead
1935	1 ounce	9	22.2	—	–
	2 ounces	8	12.5	- -	
	Check	18	0.0	—	
1936	2 ounces	26	100.0	10	0
	Check	15	6.7	20	0
1938	2 ounces	89	98.9	362	17.1
	Check	66	0.0	337	0.0

*Determined by Dr. H. H. Ross as *Scolytus rugulosus* Ratz.

from the openings for the gas to penetrate. It appears necessary to treat when the beetles have first attacked the trees and before they have laid eggs.

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